

## **Chapter 4.3**

### **Dissolved oxygen status and trends in the Maryland Coastal Bays**

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#### **Abstract**

Although the Coastal Bays are shallow lagoons that typically do not stratify, dissolved oxygen (DO) concentrations were frequently low in some areas. Daytime measurements showed DO less than 5 mg/L during the summer throughout the St. Martin River and areas of Newport Bay, as well as in Manklin Creek, Herring Creek, Turville Creek, and areas of Chincoteague Bay. Diel data showed DO less than 5 mg/L frequently in tributaries (40-60 percent of the time), but less often in the open bays.

#### **Introduction**

Dissolved oxygen (DO) concentration in water is often used to gauge the overall health of the aquatic environment. Oxygen is needed to maintain suitable fisheries habitat. When excessive amounts of algae die and sink to the bottom, bacteria decompose the material and consume oxygen. Dissolved oxygen concentrations near the bottom are often lowest. The low levels of DO that result can impair the feeding, growth, and reproduction of aquatic life in the bays. Organisms that cannot move about easily may die. Fish and crabs generally detect and avoid areas with low DO. Oxygen concentrations that are avoided (around 5 mg/L for most species) tend to be two to three times higher than lethal DO levels.

Daytime DO measurements are problematic in a non-stratified embayment. Since the Coastal Bays are shallow and generally well-mixed bays, low DO does not typically persist for long periods of time and cannot generally be measured by daytime measurements alone. Also, exceedingly high daytime DO levels often surpass threshold levels and then crash at night. Daily oxygen fluctuations in the Coastal Bays vary between one and six mg/L/day depending on season and chlorophyll abundance (Wazniak 2002). Minimum DO levels occur in the early to mid-morning, and monitoring programs typically do not collect samples until between 9 am and 2 pm. Other factors that may impact the use of daytime DO as a primary indicator of eutrophic impacts include naturally low DO in areas with extensive marshes (especially at ebb tide) and the abundance of benthic algae. Some areas are also suspected to have high sediment oxygen demand.

Maryland state water quality criteria require a minimum DO concentration of 5 mg/L at all times (COMAR 1995). This water quality standard is needed for the following aquatic target species in the Coastal Bays: hard clam (*Mercenaria mercenaria*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), white perch (*Morone americana*), and striped bass (*Morone saxatilis*) (Funderburk *et al.* 1991). Blue crabs (*Callinectes sapidus*), bay anchovies (*Anchoa mitchelli*), and alewife and blueback herring juveniles need a minimum of 3 mg/L DO. More tolerant species such as spot (*Leiostomus xanthurus*) and Atlantic menhaden (*Brevoortia tyrannus*) need a minimum of 2 mg/L and 1.1 mg/L, respectively, before significant mortalities occur (Funderburk *et al.* 1991). While these species may survive at such low oxygen values, they will not grow or reproduce.

### Data Sets

Oxygen levels at fixed sampling stations were monitored monthly during the day by the Maryland Department of Natural Resources (DNR) and the National Park Service, Assateague Island National Seashore (ASIS). Diel oxygen measurements were also made by DNR and ASIS, including a DNR pilot study in 2001 using short deployments (five to seven days) with continuous monitors. Two DNR continuous monitoring sites (one on Bishopville Prong and one on Turville Creek) have been operational since 2002, and two ASIS intensive diel surveys (10 days) at three sites (Trappe Creek, Public Landing, and Taylor Landing) were conducted in 2003. QA issues with NPS continuous monitoring data did not allow analyses of diel data from the three tide gage sites.

Intensive spatial monitoring was conducted through the following projects: seasonal macroalgae monitoring in 2002 and 2003 and the National Coastal Assessment intensive August surveys in 2002 (>100 sites) and 2003 (154 sites) (data not included). Additionally, DO was measured using DataFlow in 2003 throughout the bays (except most of Chincoteague Bay); however, these data were collected in surface water only.

Trends were not determined for DO due to the temporal variability of sample collection (time of day measurements taken were not consistent across sampling programs).

**Management Objective:** To maintain suitable fisheries (all benthic community) habitat.

**DO Indicator 1:** Minimum of 5 mg/L during diurnal (day)

**DO Indicator 2:** Minimum of 3 mg/L at any time

### Analyses

Fixed Monitoring Data: A median dissolved oxygen concentration was determined for the summer season (July, August, and September) for the three year period

from 2001-2003 for each fixed station monitoring station (Figure 4.3.1). The Maryland Coastal Bays Scientific and Technical Advisory Committee (STAC) developed criteria for threshold categories based on living resources indicators. Based on these criteria, threshold categories were determined (Table 4.3.1). Each median value was compared to each cutoff value from Table 4.3.1 by non-parametric Wilcoxon test. Those medians that were significantly different at  $p=0.01$  from the two cutoffs between which they fell were considered statistically significant overall.

Data were also analyzed for instantaneous minimum oxygen observations between 2001 and 2003. Values at or below 3 mg/L were considered to be detrimental to living resources.

**Continuous Monitoring Data:** Dissolved oxygen concentrations from two DNR continuous monitors for the years 2002, and 2003 were analyzed for the percent time the concentrations fell below the 5 and 3 mg/L thresholds.

**Spatially Monitoring Data:** DataFlow data were not included here because methods to temporally standardize the data to daily minimums are currently under development and review. Summer DO from intensive spatial macroalgae sampling in 2001 is presented here in lieu of a DataFlow analysis.

**Table 4.3.1:** Threshold category values for dissolved oxygen concentration in the Maryland Coastal Bays. Threshold cutoff values are shown. Bolded values are living resources and dissolved oxygen indicator values as suggested by STAC (see text above).

Threshold criteria category	Dissolved oxygen cutoff values for threshold category
Better than living resources objective	> 7 mg/L
Meets living resources objective	> 6 mg/L
Borderline living resources objective	> <b>5 mg/L</b>
Living resources threatened	> <b>3 mg/L</b>
Does not meet objectives	< 3 mg/L

#### Status of dissolved oxygen

The status of dissolved oxygen by Coastal Bays segment is given below. Please view Figure 4.2.1 for place names and stations listed in text.

**Table 4.3.2:** Summary of summer dissolved oxygen (June – September) from continuous monitoring data collected in Bishopville Prong and Turville Creek during 2002 and 2003. The percent of time threshold levels were not met was calculated from data collected between June to December in 2002 and 2003 results were calculated from data collected between March 26 and November 30.

Site	Indicator and Threshold Level	2002 results	2003 results
Bishopville Prong	DO < 5	59.%	66%
	DO < 3	30%	47%
Turville Creek	DO < 5	39%	39%
	DO < 3	7%	11%

#### *Assawoman Bay*

All fixed sites met the summer median threshold of 5 mg/L (Figure 4.3.2); however, minimum daytime values between 3-5 mg/L were observed at stations XDN7545, XDN6454, and GET0005 (Figure 4.3.3).

No continuous monitoring data were available. Threshold failures may be present if diel measurements were available, since daytime values were frequently between 5 and 6 mg/L.

Spatially-intensive data revealed a majority of Assawoman Bay meeting the DO threshold (Figure 4.3.4). A few sites along the southern approach to Grey's Creek, in dead-end canals along Fenwick Island, and on the approach to Roy's Creek in Delaware did not meet the 5 mg/L threshold.

#### *St. Martin River*

Two sites, Bishopville Prong (XDM4486) and mainstem river (XDN4312), failed the three year median of <5 mg/L, but no site had a summer median of less than 3mg/l (Figure 4.3.2). Instantaneous minimum values of < 3mg/L were observed throughout the river (Figure 4.3.3).

The continuous monitoring station on Bishopville Prong did not meet DO thresholds, 5 and 3 mg/L, 59.3% and 29.5% of the time, respectively, in 2002, a dry year (Table 4.3.2). In 2003, a wet year, DO thresholds failed 66% and 47% of the time between March 1 and November 30 (Table 4.3.2).

During August of 2001, spatially intensive sampling showed that a majority of the St. Martin River did not meet the DO threshold (Figure 4.3.4). Several sites in the upper tributaries fell below 3 mg/L.

#### *Isle of Wight Bay*

All open bay sites met >5 mg/L threshold but tributary stations in Manklin Creek (MKL0010) and Turville Creek (TUV0011 and TUV0019) failed the median of 5

mg/L (Figure 4.3.2). The Manklin Creek site had a summer median of < 3 mg/L. This station had sustained low DO due to its depth (Figure 4.3.3).

Two sites failed the instantaneous minimum of 3 mg/L in Manklin Creek (instantaneous value < 1.5 mg/L), as well as one non-tidal site on Turville Creek (TUV0034) (Figure 4.3.2).

Continuous monitoring data on Turville Creek showed that the 5 and 3 mg/L criteria were not met 39% and 7.4% of the time in 2002, respectively. In 2003, DO thresholds failed 39 and 11% of the time (Table 4.3.2).

Most of the Isle of Wight Bay proper met the DO threshold during spatially intensive sampling (Figure 4.3.5). However, areas in Manklin, Turville, and Herring Creeks were mostly below the threshold level.

#### *Sinepuxent Bay*

All sites met the summer median threshold of >5 mg/L and the instantaneous minimum threshold of 3 mg/l (Figures 4.3.2, 4.3.3, and 4.3.4 respectfully).

No continuous monitoring data were available. Some thresholds may not have been met if diel data were available since daytime values were frequently between 5 and 6 mg/L DO.

A majority of Sinepuxent Bay had DO levels above the threshold during spatially intensive sampling (Figure 4.3.5). One area that failed the threshold was located in the commercial harbor opposite the Ocean City Inlet. A few other sites failed along the western shore of this bay segment.

#### *Newport Bay*

All stations met the > 5 mg/L summer median except Marshall Creek (MSL0011) and the mouth of Newport Creek (NPC0012) (Figure 4.3.2).

Marshall creek and the mouth of Newport Creek failed the instantaneous minimum of 3 mg/L threshold (Figure 4.3.3).

Fluctuations in DO were investigated by ASIS over three time periods at a site on Trappe Creek during 2003. Dissolved oxygen concentrations during June fluctuated by as much as 5 mg/L during one day/night cycle and DO fell below 5 mg/L 12 percent of the time. During the July/August deployment, similar fluctuations during a diel period were noted and 40 percent of the values did not meet the 5 mg/l threshold. During mid-September, water temperatures moderated from summer highs and diel fluctuations of dissolved oxygen values were much smaller and all values were above threshold levels.

Varying DO levels were recorded during spatially intensive sampling (Figure 4.3.4). All sites in Trappe Creek failed the threshold. The open bay had an east-west gradient of passing to failing the DO threshold.

#### *Chincoteague Bay*

All sites met summer median of 5 mg/L threshold and instantaneous minimum >3 mg/l thresholds (Figures 4.3.2 and 4.3.3, respectfully). Mid-bay stations may fail threshold if diel data were collected since daytime values frequently between 5 and 6 mg/L.

Dissolved oxygen was measured at Taylor Landing as part of a study initiated by ASIS during the summer of 2003. During the first sampling period (June), dissolved oxygen concentrations fluctuated widely during each diel period with concentrations dropping below threshold levels three percent of the total time. The second sampling period also had widely fluctuating DO concentrations with seven percent of samples being below habitat criteria. Fluctuations in DO concentration were not as large during the fall sampling period (mid-September). No values were found below threshold levels during this time period.

Most of Chincoteague Bay met the DO threshold during spatially intensive sampling. Those sites that failed were mostly in coves or along the shoreline, especially around Figgs Landing and Green Run Bay.

### **Summary**

Although the Coastal Bays are shallow lagoons, which typically do not stratify, oxygen values were found to be frequently low in some areas. Daytime measurements show that DO falls below 5 mg/L during the summer months throughout the St. Martin River and areas of Newport Bay, as well as in Manklin Creek, Herring Creek, Turville Creek and areas in Chincoteague Bay near Figgs Landing and Green Run Bay (macroalgae spatial data). Areas that have <5 mg/L DO during the day may provide extremely stressful habitat at night.

Diel data showed that DO is frequently less than the 5 mg/L threshold in the tributaries (40 – 60% of the time in Turville Creek and Bishopville Prong).

Observed low DO values were presumably due to the respiration of large algae blooms (caused by increased nutrients), high sediment oxygen demand from organically enriched sediments in many areas (Wells and Conkwright 1999; UMCES 2004), the decay of phytoplankton, macroalgae, seagrasses, and/or marsh vegetation, and poor circulation.

Dissolved oxygen indicators can be problematic in an unstratified, shallow system especially when relying primarily on daytime measurements (which can be highly variable). One recommendation is that continuous monitors be placed in all bay segments to better track low oxygen events that can impact resources.

## References

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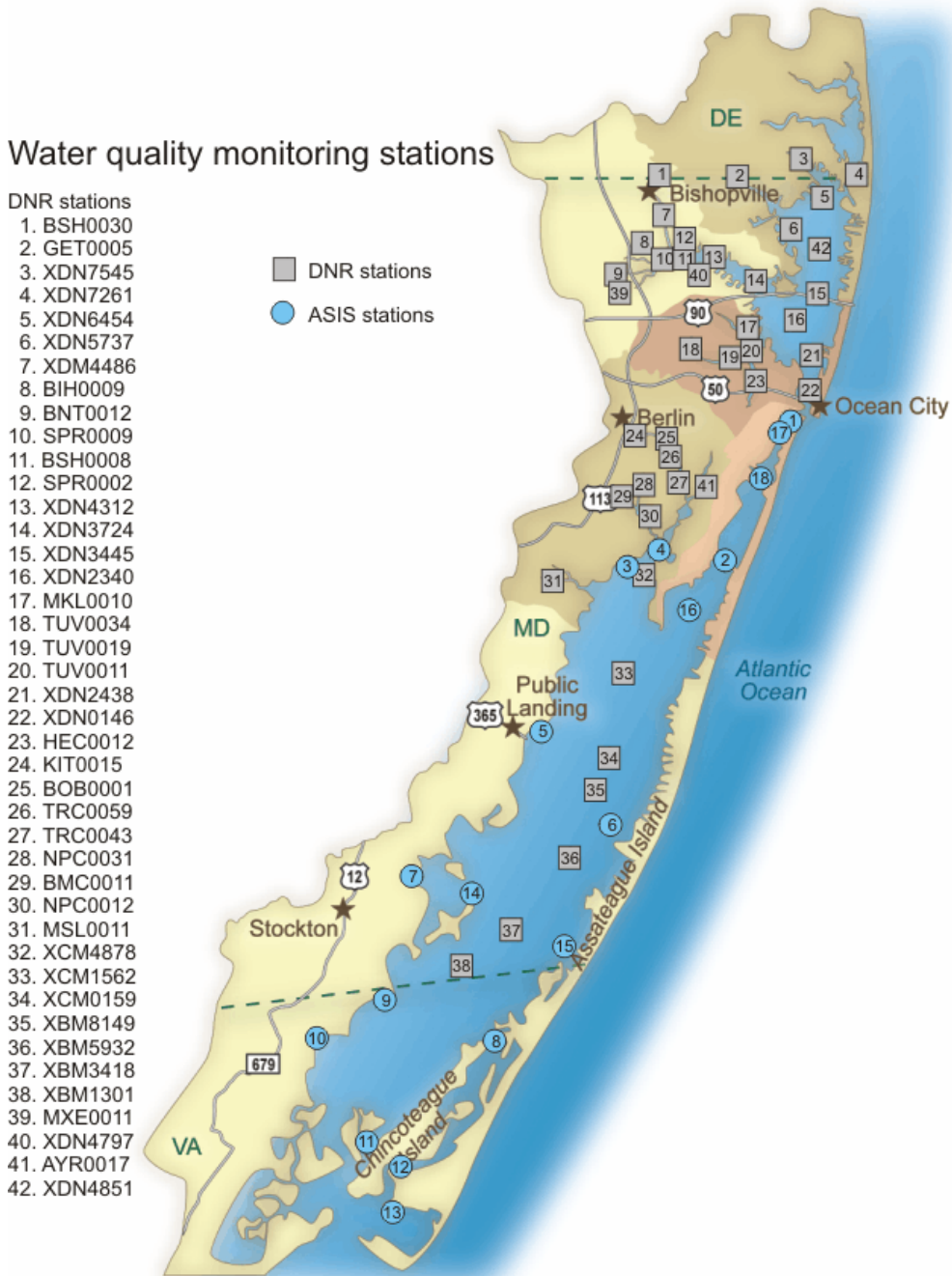


Figure 4.3.1: Map showing water quality monitoring stations for the Maryland Department of Natural Resources (DNR) and the National Park Service, Assateague Island National Seashore (ASIS). DNR stations are listed by DNR code; ASIS stations are referred to as ASIS or MCBP and the station number (for example, ASIS 1).





Figure 4.3.2: Median concentrations of Dissolved Oxygen in Coastal Bays fixed monitoring stations during the summers (June-September) of 2001 through 2003. Status categories are based on threshold values described in the text.

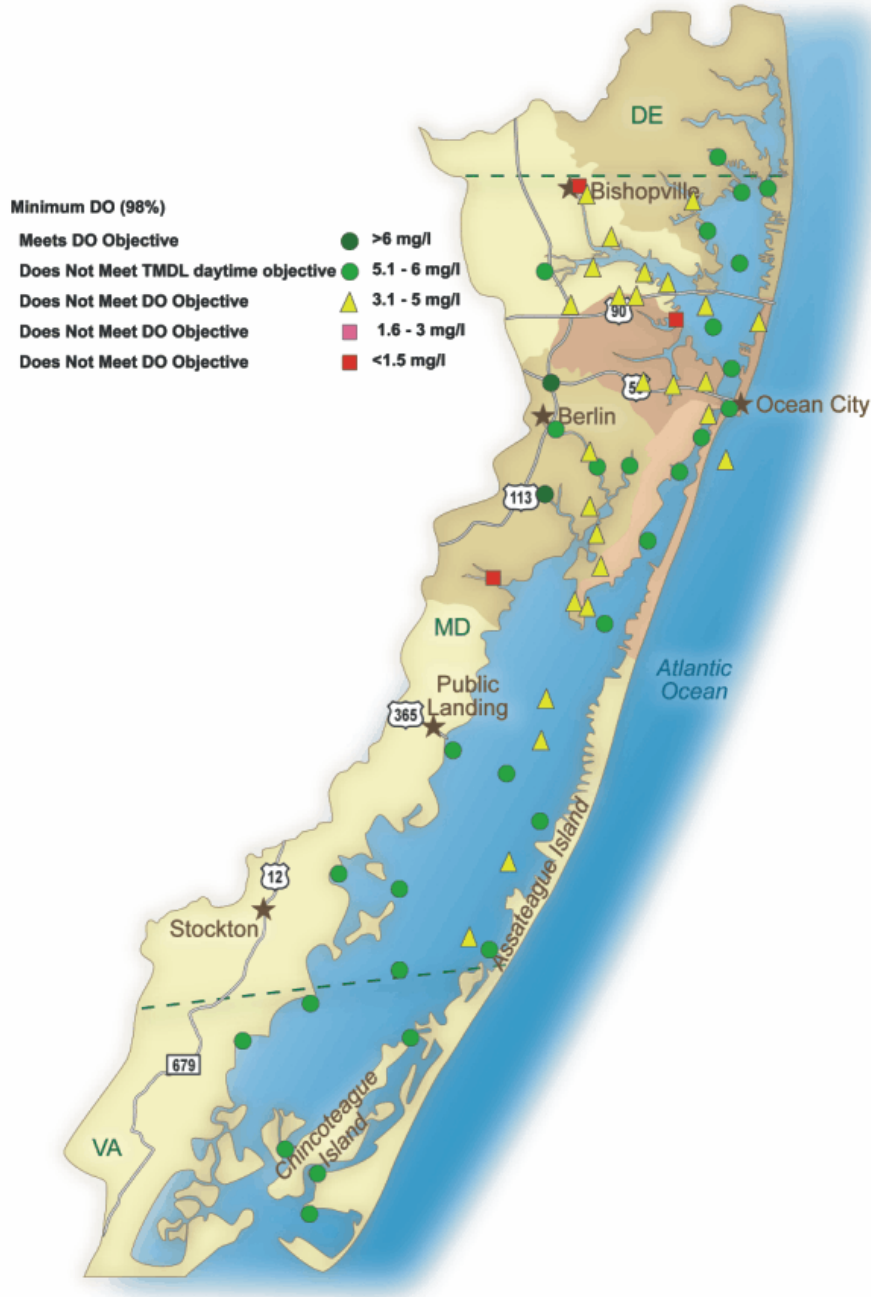


Figure 4.3.3: Minimum concentrations of Dissolved Oxygen (DO) in Coastal Bays fixed monitoring stations during the summers (June-September) of 2001 through 2003, only those minimum values falling within 98% confidence limits were included. Objectives were determined by TMDL analyses conducted for Newport Bay and St. Martin River.

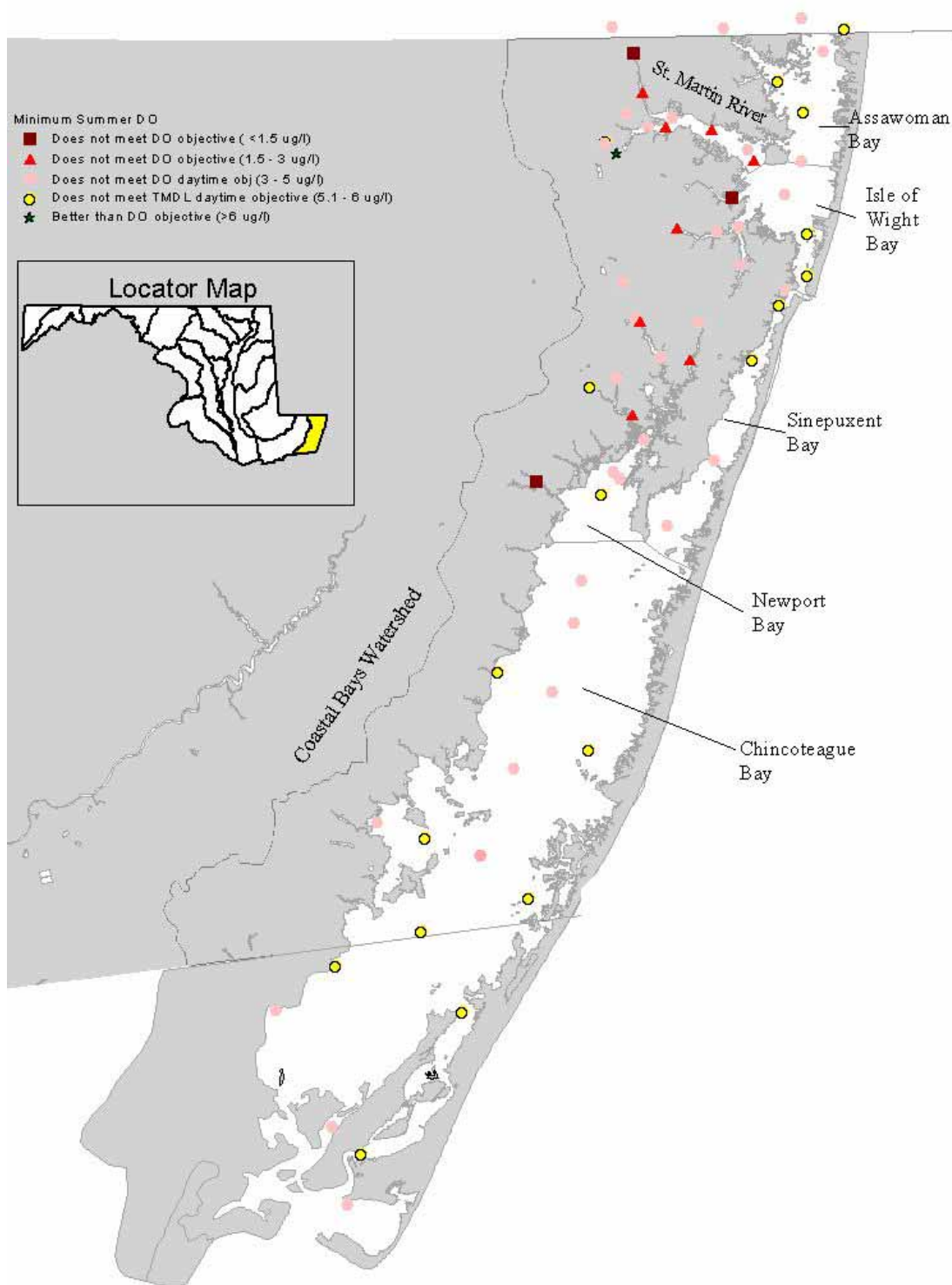


Figure 4.3.4: Observed minimum concentration of Dissolved Oxygen (DO) at Coastal Bays fixed monitoring stations during the summer months (June-September) of 2001 through 2003.

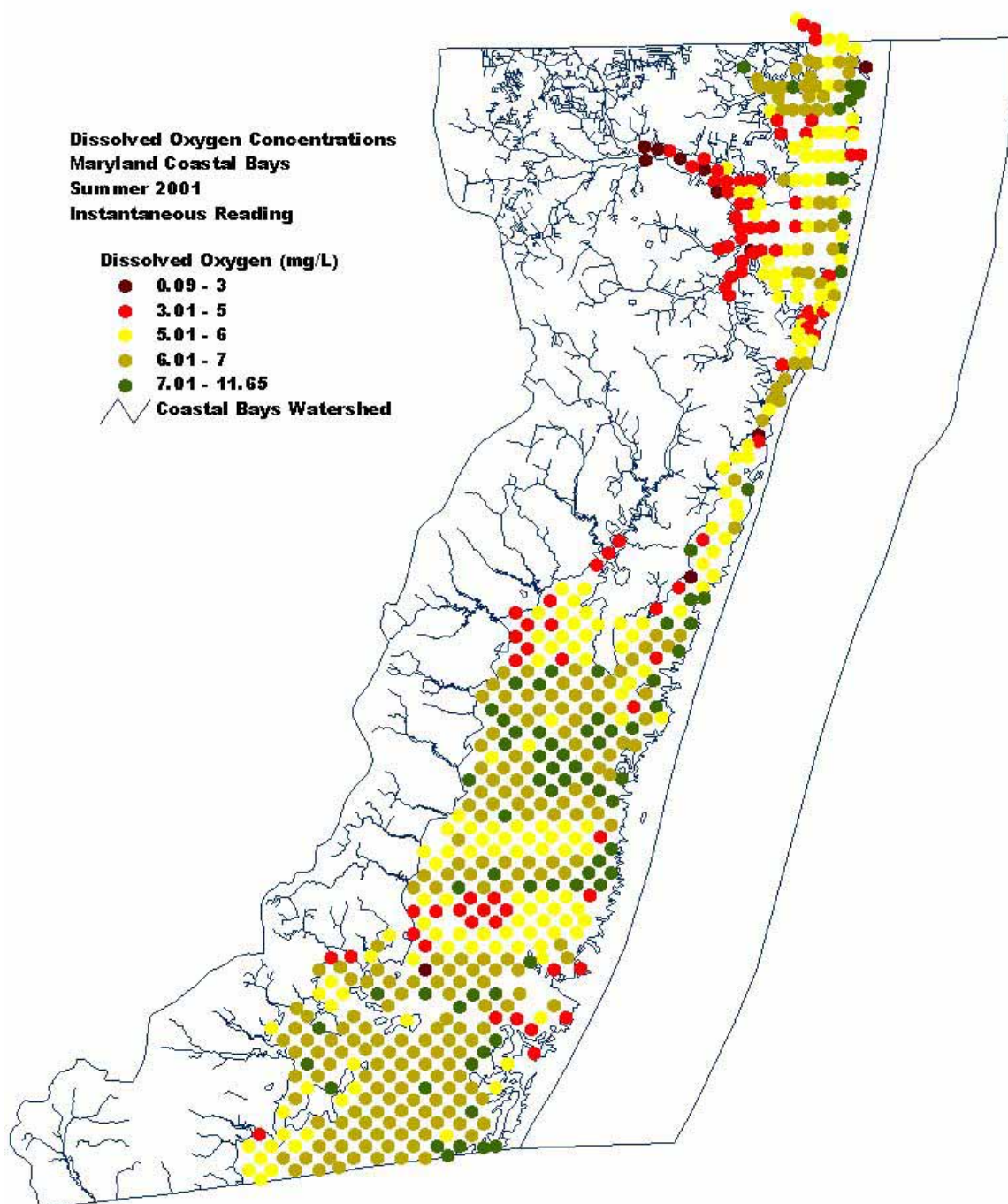


Figure 4.3.5: Instantaneous DO measurements taken during summer macroalgae sampling in August of 2001. This data provides a spatially intensive snapshot of late summer DO levels. Map created by M. McGinty (DNR).